EXHIBIT A

Excerpts from Streetman, Ben G., Solid State Electronic Device, Prentice-Hall, Inc., 1980, page 67.

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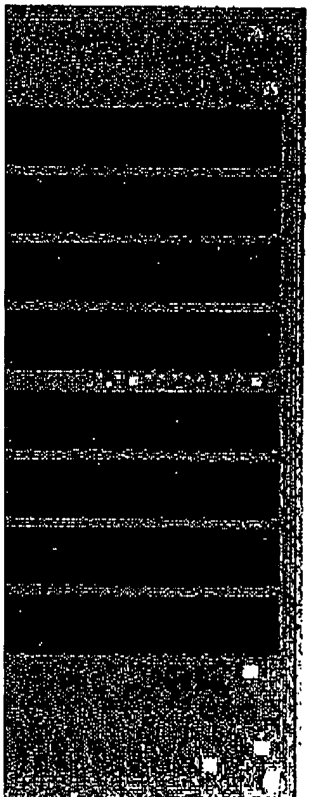

'cuit chip employs charge-coupled This is achieved with 16 memories of 1ip (0.27 cm²). An additional 4 k-bit als, and peripheral input–output and modern integrated circuit technology which cannot be understood without evices. The purpose of this book is to er understand and use the solid state esy of Texas Instruments, Inc.)

SOLID STATE ELECTRONIC DEVICES

second edition

BEN G. STREETMAN

Department of Electrical Engineering
The University of Texas at Austin

PRENTICE-HALL, INC., Englewood Cliffs, New Jersey 07632

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ken away from its position in the bond
to move about in the lattice, a conducti
bond (holo) is left behind. The
band gap energy E_g. This model help
m of EHP creation, but the energy ba
urposes of quantitative calculation. O
bond" model is that the free electron a
d in the lattice. Actually, the position
e spread out over several lattice spaci
mechanically by probability distributio

are created in pairs, the conduction
s per cm³) is equal to the concent
les per cm³). Each of these intrinsic
ed to as n_i. Thus *for intrinsic materia*

$$= p = n_i \qquad (3$$

ertain concentration of electron–hole p
ier concentration is maintained, there
same rate at which they are gene
lectron in the conduction band mak
n empty state (hole) in the valence ba
lenote the generation rate of EHP's a
tion rate as r_i, equilibrium requires tha

$$r_i = g_i \qquad (3$$

dependent. For example, $g_i(T)$ increa
ld a new carrier concentration n_i is est
ination rate $r_i(T)$ just balances generatio
that the rate of recombination of ele
equilibrium concentration of electro

$$_0p_0 = \alpha_r n_i^2 = g_i \qquad (3$$

rtionality which depends on the particu
n takes place. We shall discuss the calcu
ture in Section 3.3.3; recombination p
4.

arriers generated thermally, it is po
s by purposely introducing impuriti
oping, is the most common techniq

the conductivity of semiconductors. By doping, a crystal can be so that it has a predominance of either electrons or holes. Thus there types of doped semiconductors, n-type (mostly electrons) and p-type holes). When a crystal is doped such that the equilibrium carrier tions n_0 and p_0 are different from the intrinsic carrier concentration material is said to be *extrinsic*.

impurities or lattice defects are introduced into an otherwise ystal, additional levels are created in the energy band structure, within the band gap. For example, an impurity from column V of odic table (P, As, and Sb) introduces an energy level very near the tion band in Ge or Si. This level is filled with electrons at 0°K, and tle thermal energy is required to excite these electrons to the conduc- nd (Fig. 3-11). Thus at about 50–100°K virtually all of the electrons purity level are "donated" to the conduction band. Such an impurity called a *donor* level, and the column V impurities in Ge or Si are called impurities. From Fig. 3-11 we note that material doped with donor ies can have a considerable concentration of electrons in the conduc- nd, even when the temperature is too low for the intrinsic EHP tion to be appreciable. Thus semiconductors doped with a signif-

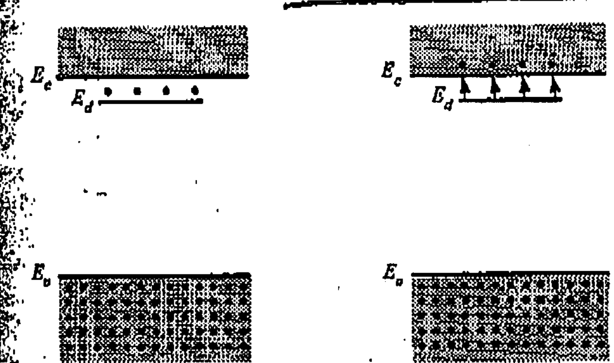

Figure 3-11. Donation of electrons from a donor level to the conduc- tion band.

mber of donor atoms will have $n_0 \gg (n_i, p_0)$ at room temperature material.

oms from column III (B, Al, Ga, and In) introduce impurity levels Si near the valence band. These levels are empty of electrons at g. 3-12). At low temperatures, enough thermal energy is available electr ns from the valence band into the impurity level, leaving holes in the valence band. Since this type of impurity level "accepts"